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# THE CONTRIBUTION OF CHEMURGY

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# ABSTRACT

Chemurgy is defined as the application of science and technology to the processing of agricultural commodities for both food and non-food purposes. The value of chemurgic advances made by countries other than the United States is acknowledged. Chemurgic objectives are discussed, and it is indicated that their attainment involves further development of traditional methods of utilizing farm products as well as discovery and exploitation of new industrial uses for agricultural materials.

The importance of modern food technology as a chemurgic endeavor to create and conserve food resources is pointed out. Several recent developments in food preservation are described.

The processing of agricultural commodities to recover and utilize their constituents in food and feed products and as industrial raw materials is discussed. The wet-milling of corn (maize) and grain sorghum and the processing of soybeans and other oilseeds are cited as examples of chemurgic enterprise in this field. New developments in fermentation and in the utilization of alcohol as motor fuel are mentioned.

Reference is made to facilities and information available in the United States to aid in the chemurgic training of scientists and technicians of other countries. It is emphasized that progress in chemurgy depends upon coordinated effort in many fields, and that efficient agricultural production, adequate scientific research, advanced technology, and aggressive industrial enterprise all contribute to chemurgic success.

# THE CONTRIBUTION OF CHEMURGY

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## I

I am honored to have the privilege of discussing with this distinguished international group the contribution of chemurgy to the conservation and wise utilization of agricultural resources. The term "chemurgy" is hard to define precisely, but I shall interpret it here to mean the application of science and technology to the industrial processing of agricultural commodities for both food and non-food purposes. Chemurgy involves an effort to use farm products and byproducts more effectively, and to create from them new resources of foods, feeds, and industrial raw materials.

In my remarks I shall speak chiefly of chemurgic developments in the United States and refer to several research contributions by my own organization, the Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture. I am well aware, however, of the important chemurgic advances made in other parts of the world and by other research organizations in this country and elsewhere. I should like to acknowledge here that we in the United States have profited greatly from the pioneering work in chemurgy done by other nations. Many of you can take justifiable pride in the chemurgic achievements of your countrymen, who have done admirable work under difficult conditions and often with very limited technical facilities.

I might mention also that certain chemurgic developments which have been highly successful in other countries are relative failures here because of the different agronomic and economic conditions that exist in this country. At the same time, we in America with our highly industrialized economy have been able to engage profitably in some chemurgic operations that so far have not proved feasible for nations of less advanced industrial development. But despite the different problems faced by different countries, I believe chemurgy is a subject that concerns us all. If my remarks can help in some degree to stimulate international interest in chemurgy and to encourage international cooperation in chemurgic endeavors, I believe we shall all benefit.

The word "chemurgy" was coined about fifteen years ago to express with convenient brevity a complex idea -- the idea of developing new industrial uses for farm commodities, of establishing new crops to supply industrial markets, and of making profitable use of farm wastes and residues. A fundamental premise of chemurgy is that farm and forest products can be reproduced, while mineral resources cannot. Chemurgy is based on the living and lasting foundation of agricultural production. It proposes that we should try to develop practical means of substituting *reproducible* products of the soil for at least some of our *unrenewable* resources, including coal and petroleum. Another basic chemurgic principle is that while man's need for food is limited his appetite for industrial products seems virtually insatiable. Proponents of the chemurgic idea in the United States during the 1930's visualized that by creating new industrial outlets for farm commodities, and by providing farmers with new crops to be grown specifically for industrial uses, it might be possible to eliminate burdensome crop surpluses. The chemurgists were acutely aware also that in traditional practice about half our total output of farm-grown materials is unmarketable waste. They emphasized the need for converting farm residues such as wheat straw, corncobs, and vegetable and fruit wastes into useful products.

In these essentials the chemurgic idea has not changed much since it was first propounded. Nevertheless, the general concept of chemurgy has tended gradually to broaden. As Wheeler McMillen, the outstanding spokesman for the chemurgic movement in this country, stated recently, "The definition of chemurgy keeps bursting out at the seams." Chemurgic objectives include the development of wider markets for farm-grown materials and the creation of "new riches from the soil". These objectives are hardly new -- they have challenged man's ingenuity for centuries, perhaps since the beginning of agriculture itself. But chemurgy seeks to attain them by new methods, based on the latest advances in chemistry and allied sciences, and with the aid of modern engineering. It is evident that achievement of these chemurgic aims requires the expansion and further development of *traditional* methods of utilizing farm products, for food and other purposes, as well as the discovery and exploitation of *new* industrial, non-food uses for them.

## II

If we accept this general concept of the meaning and purpose of chemurgy, it appears that modern techniques of food preservation constitute one very important field of chemurgic effort. Converting fruits and vegetables into more stable form by canning, freezing, and other methods lengthens the season and expands the area in which these perishable farm products can be made available, thus providing wider markets for the farmer and greater food resources for consumers. It is also a partial answer to some of our most persistent farm-surplus problems -- the geographical and seasonal surpluses of perishable crops that often occur in limited areas for short seasons.

It seems to me that the international importance of recent developments in food preservation can hardly be overestimated. If modern food technology could be applied more widely throughout the world, it could raise substantially the nutritional standards of millions of people. The major techniques of food preservation -- dehydration, canning, and freezing -- are generally familiar to you all. We are continuing through research to improve each of these methods, to extend their use to a greater variety of farm commodities, and to increase the palatability and food value of the finished products. I should like to mention two or three new developments along this line which have potentially wide application. Although these particular accomplishments are perhaps not of great immediate significance from the standpoint of total world food supply, they are interesting as examples of modern progress in food technology.

As you know, the most spectacular recent advances in food preservation have been made in the field of frozen foods. They now make it possible for most housewives in the United States to serve fruits and vegetables of many kinds virtually "field fresh" at any season. One new product, the result of applying a new principle of food preservation, is **frozen concentrated orange juice.** Its production this year -- some 7 or

8 million gallons -- will consume about 10 percent of the orange crop in Florida, as well as a portion of the California crop. This concentrate, when mixed with water, makes orange juice that is almost identical in flavor and nutritional value to fresh orange juice. Yet the concentrate itself has only one-quarter to one-third the bulk of the fresh juice and will keep satisfactorily in frozen storage for more than a year. Both grape and grapefruit juices are now processed commercially in this way. The new method of concentration and freezing might be extended with advantage to other fruits, particularly some of those produced in the tropics.

Another development of considerable promise, now in an advanced stage of experimentation, is **dehydrofreezing.** This process combines the virtues of quick-freezing fruits and vegetables with the advantages of reduced weight and bulk made possible by partial dehydration. Dehydrofrozen peas, apples, apricots, and other products have excellent flavor and are easy to reconstitute in the kitchen. They occupy only about half the space in frozen storage and have about half the weight of conventionally frozen products. Experimental results show that the additional costs involved in drying are more than offset by savings in packaging, transporting, and storing these new products.

Still another new development is a method for recovering and concentrating the natural **flavor essences** of apples and other fruits. In manufacturing many fruit products, the full flavor of the fresh fruit is often completely lost. But now equipment and techniques have been devised for capturing the volatile flavor constituents of fresh fruits, so that they can later be added to fruit products in the final stages of processing to give them better flavor. Commercial production of apple essence by this method is already underway, and the process is applicable to many other fruits. Like the production of frozen fruit concentrates, the recovery and concentration of fruit essences -- particularly those of various delectable tropical fruits, which have not yet found a place in international trade -- has promising possibilities.

## III

Besides giving us new techniques of food preservation, chemurgy has contributed greatly to our wealth of "creatable resources" through the processing of farm products to obtain starches, sugars, oils, proteins, and other constituents that can be used in the manufacture of foods and feeds and as industrial raw materials. The wet-milling of corn, or maize, and the processing of soybeans and other oilseeds are major chemurgic enterprises of this kind.

The **corn refining,** or wet-milling, industry achieves almost complete utilization of one agricultural product, the maize kernel. This industry consumes substantially more than 100 million bushels of maize each year. Its output of sugar, starch, corn oil, gluten, and other materials -- which totals several billion pounds annually -- finds scores of industrial, food, and feed uses.

A new chemurgic crop of increasing importance today is **grain sorghum.** It grows better than maize in semi-arid climates and is therefore of particular interest to farmers in the southwestern United States. Research has given us a wet-milling process for grain sorghum and laid the foundation for a new industry in the American Southwest. One large plant in Texas is now producing starch, commercial feeds, sweeteners, fermentable sugars, and vegetable oil from this grain.

The soybean is the outstanding example of a crop recently introduced into the United States which has achieved true chemurgic success. As you know, soybean oil, protein, and other constituents are now used in literally hundreds of food and industrial products. When World War II cut off American imports of vegetable oils and fats from the Far East, the soybean was the only domestic oilseed that could be grown in sufficient quantity to meet the deficit. Production of this crop was almost tripled during the war, and in 1947 it reached a record total of 1½ billion pounds of soybeans. This agricultural achievement of the Midwest has made it possible for the United States to help supply Europe with badly needed vegetable fats and oil in the years since the war.

A great deal of research still needs to be done to develop improved methods of processing soybeans, to increase the flavor stability of soybean oil so that its food uses can be expanded, and to improve the drying quality of the oil for wider use in paints and other protective coatings. The fermentation of soybean meal to produce high-protein "cheeses" and similar products -- which have long been important in Chinese diets -- is now receiving attention in this country. This method of utilizing the soybean should be of especial interest to countries that have critical shortages of animal proteins.

The same type of research that is helping to expand markets for soybeans in the Midwest is being applied to problems of processing and utilizing peanuts and cottonseed in the South. Adaption of solvent-extraction procedures to these important oilseeds is a major objective of current research in this field. The future of chemurgy in the southern United States seems generally bright, and developments in this region may well provide the key to chemurgic expansion in other areas of the world with a similar climate.

Perhaps the most important chemurgic development in the United States during the last few years has been the tremendous expansion in the **fermentation industries**, which produce antibiotics, feed yeast, vitamins, industrial alcohol, and other needed products. A great impetus was given to developments in this entire field by the discovery of penicillin and the perfection of methods for the large-scale production of this vital drug by submerged-culture fermentation. The fermentation industries provide, among other things, substantial outlets for agricultural wastes and byproducts. Millions of pounds of corn steepwater, a byproduct of the wet-milling of maize, and lactose, or milk sugar, a byproduct of butter and cheese manufacture, are now used as nutrients for growing the microorganisms that produce penicillin and streptomycin. Fruit pulp and waste juices from the fruit-preserving industry are other agricultural wastes that find use in fermentation processes.

One interesting new development in fermentation is the production of mushroom spawn in submerged culture. This product has as good nutritional quality as food yeast and can be grown in equal quantities by similar methods. But this type of mushroom mycelium is superior in flavor to yeast -- it tastes like ordinary mushrooms. Riboflavin, or vitamin $B_2$, is another new product of fermentation. An intensive search is now underway in the United States to find a microorganism that will produce vitamin $B_{12}$, the "animal protein factor" or anti-pernicious-anemia vitamin. This substance has been furnished in livestock feeds chiefly by meat scraps and fish meal, but these materials have recently been in short supply.

No discussion of chemurgy would be complete without some mention of the production of **industrial alcohol** from grains and other agricultural materials and its use as a supplementary motor fuel. This is a complex subject and I can only touch on it briefly here. A tremendous amount of work is being done in the United States to develop new and cheaper methods of producing alcohol and to utilize it as motor fuel. Perhaps the most significant development in this field, which may be of interest to many countries, is the use of alcohol as an anti-knock agent in engines by direct, automatic injection into the engine manifolds of automotive vehicles.

Until recently, alcohol has been employed as motor fuel chiefly in blend with gasoline, and a number of other countries have had more practical experience with this method than has the United States. The advantage of the direct-injection method is that the alcohol is used only when needed -- that is, when the automobile or other vehicle is under heavy load, as in starting, accelerating, or climbing hills. This occurs only during about 5 percent of normal driving time. Using alcohol in this manner as an anti-knock agent permits efficient use of relatively low-octane gasoline as the main fuel. If widely adopted, this procedure could make possible a significant extension of a nation's petroleum resources.

## IV

In this brief discussion I have had time to mention only a few of the highlights of chemurgy's present and potential contribution to the conservation and use of agricultural resources and to the creation of new resources. I have tried to show how chemurgy enables us to create new wealth from reproducible agricultural materials, giving rise to new industries and increasing employment. We all realize that Fortune has not dealt equally with the nations represented here in regard to the distribution of mineral resources. But the distribution of rain and sunshine and tillable soil has been in general more equitable. By making possible more efficient use of those resources and of the annually reproducible crops they yield, chemurgy can and should contribute greatly to the welfare of all countries.

Science and technology, and the facilities for making them effective, are indispensable for the achievement of world advances in chemurgy. Workers for chemurgic laboratories and factories must be trained in greater numbers in many countries. The United States is already taking steps to assist other nations with such training, in line with "Point Four" of President Truman's Inaugural Address. We have only made a beginning, and much more should be and undoubtedly will be done. My own Bureau has for some years provided laboratory training for scientists and technicians from other countries. This program is being continued, and we hope that these trainees will be able to plant the seeds of chemurgic enterprise all over the world. The Bureau has available a great deal of information on fundamental and applied chemurgic research, and we are interested in disseminating this information to all who can profit by it.

In closing I should like to emphasize that the contribution of chemurgy is made jointly by agriculture, science, and industry. Chemurgic progress can be achieved only as a result of effective coordination of many diverse lines of effort. It requires a high degree of efficiency in all phases of planting, cultivating, and harvesting crops, in processing and utilizing agricultural materials, and finally in marketing new chemurgic products. Good farming practices and soil conservation; energetic and forward-looking research; industrial enterprise and engineering "know-how"; efficient, well-organized transportation facilities; even aggressive advertising and merchandising -- all these have an important part to play in the success of chemurgic undertakings.

Although the contribution of chemurgy to the national welfare of this and other countries is already considerable, it will surely become even greater in the years ahead. We know that the crops can be produced, and that they can be converted into an increasing number of needed products. Chemurgy is an outstanding example of how freely organized human effort -- expended in agriculture, business, and industry; guided by science; and made effective through applied technology -- can create new wealth and the materials for a better human life from the world's elementary resources.

## SELECTED BIBLIOGRAPHY

Annual Lists of Publications and Patents, Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture, Washington 25, D. C. (Include publications of the Bureau's four Regional Research Laboratories.)

Annual Reports of the Chief of the Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture.

Jacobs, P. Burke. "Alcohol from Agricultural Commodities". **AIC-95**, Bureau of Agricultural and Industrial Chemistry, 1945.

Langford, Cecil T. "Recent Advances in the Fermentation Field". **CHEMURGIC DIGEST**, May 1948; pp. 4-7, 33.

Lathrop, E. C., and others. "A Small Rural Industry -- Making Insulating Board from Straw". **Circular No. 762** and **AIC-170** (two parts), Bureau of Agricultural and Industrial Chemistry, 1947.

Maclay, W.D., and Owens, H.S. "Pectinates -- Promising Food and Industrial Material". **Chemurgic Digest**, Vol. 6, No. 22, 1947; pp. 325, 327-329.

McMillen, Wheeler. **New Riches from the Soil.** D. Van Nostrand Co., New York, 1946.

"Regional Research Laboratories, Department of Agriculture". **Document No. 65**, U. S. Senate, 76th Congress, 1st Session, 1939. Bureau of Agricultural and Industrial Chemistry.

Scott, W. M. "Chemurgic Advances in Cotton and Peanuts". **Chemurgic Digest**, May 1949; pp. 26-28.